ACTIVITY CURVES AND THEIR PRACTICAL USE

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1. MOVEMENT ACTIVITY

The Vivago system measures the movement activity of the wrist unit's user. Measurement is made with the wrist unit's sensitive movement sensor. Both the amount and strength of movements have an affect on measurement results. A value representing activity, ranging from 0 – 100, is calculated for each minute. This value tells us the amount of the user's activity during the period of one minute. An activity value of 0 shows that the wrist unit has not registered any movement from its' user, that is, s/he has been completely motionless. A value of 100 represents the greatest amount of movement measurable by the wrist unit. This type of activity requires vigorous movements from the user.

Measurement results are transferred through a base station to a computer with the Vista program. The computer stores each user's measurement information, which can be viewed and analysed with the help of the Vista program. The program produces an activity curve for each user based on the measurements provided by the wrist unit, where one point represents one minute of activity.

The activity curve shows the users average movement activity. Based on the graph we can make conclusions about the state and well being of the user.

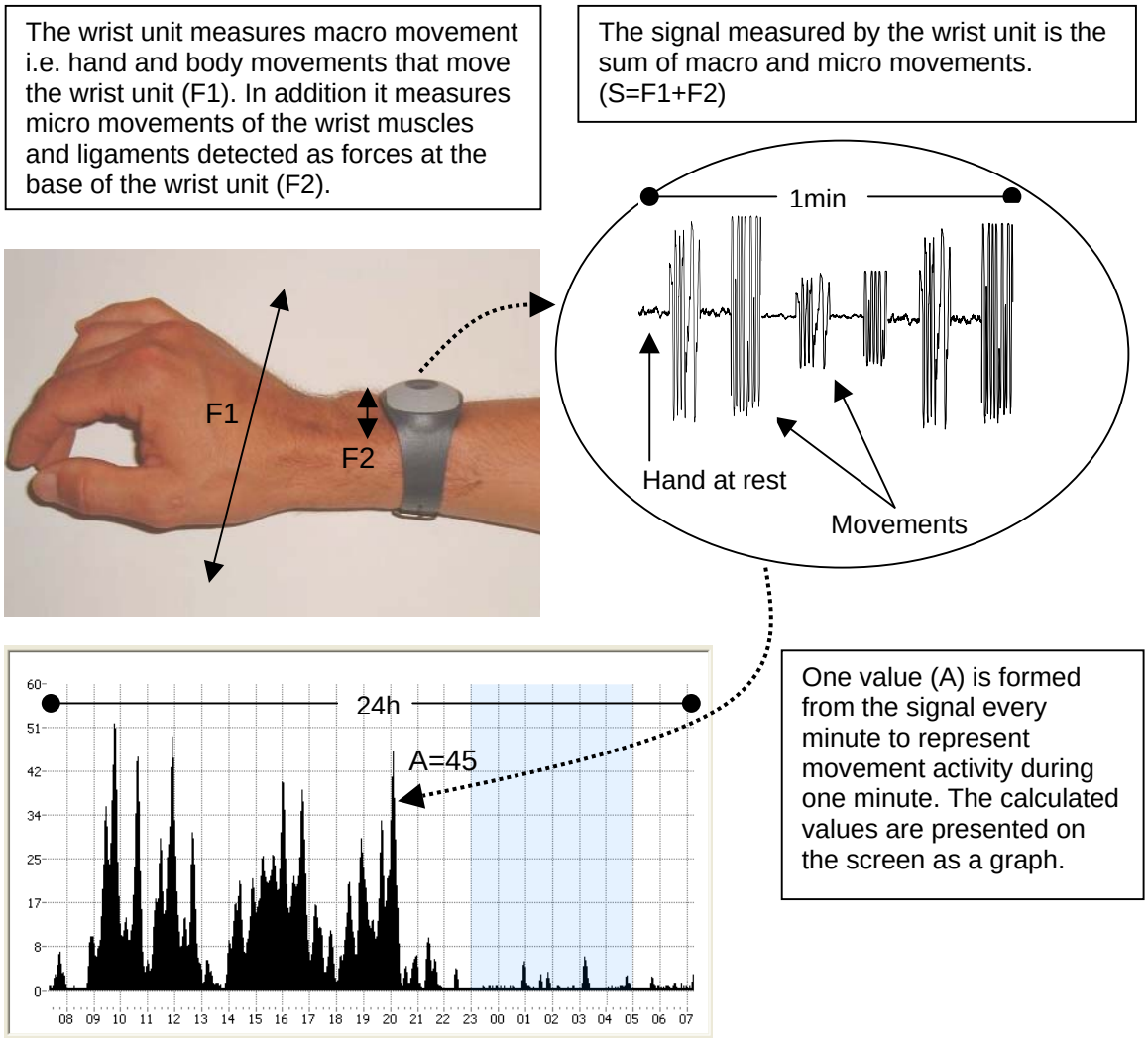

The wrist unit measures macro movement i.e. hand and body movements that move the wrist unit (F1). In addition it measures micro movements of the wrist muscles and ligaments detected as forces at the base of the wrist unit (F2).
The signal measured by the wrist unit is the sum of macro and micro movements. (S=F1+F2)
F1
F2
1min
Hand at rest
Movements
60
51
42
34
25
17
8
0
24h
A=45
08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23 00 01 02 03 04 05 06 07
One value (A) is formed from the signal every minute to represent movement activity during one minute. The calculated values are presented on the screen as a graph.

Figure 1. Movement activity

2. ACTIVITY CURVES IN THE ANALYSIS OF CIRCADIAN RHYTHM AND SLEEP

Circadian rhythm and sleep can be analysed with the aid of activity curves derived from activity measurement (figure 2).

A person's circadian rhythm and sleep quality, as well as daily activity reflect their state of health and well being. In poor health, a person sleeps restlessly and is tired during the day. Many changes in state of health or functional ability can be detected from changes in circadian rhythm and sleep, and thus also on the measured activity curve. Continuous observation is important because it enables the detection of changes in the activity curve. Necessary care can then be given immediately and its effectiveness can be evaluated.

Activity curve observation cannot render a specific diagnosis because many ailments appear similarly on the curve as, for example, nighttime awakenings. It is not very often possible to say that a certain ailment would appear on the graph in its own particular way. Sometimes a certain change in the state of health, such as back pains, may induce individual changes in circadian rhythm and sleep. One may wake up during the night another is tired during the day. The activity curve is effective in 1) detecting general problem states, 2) evaluating the effectiveness of care when the ailment has already been identified.

The Vista program has several features that aid in the analysis of circadian rhythm and sleep. The activity curves chapter in the Vista user's manual includes a detailed description of these features. Practical instructions and examples of the effective use of available features are provided in this application guide. The pictures and curves presented in this guide have been made using Vista program version 3.0. In version 2.0 or those older, the curve is drawn and presented in a different way, and they do not contain all of the features introduced in this manual.

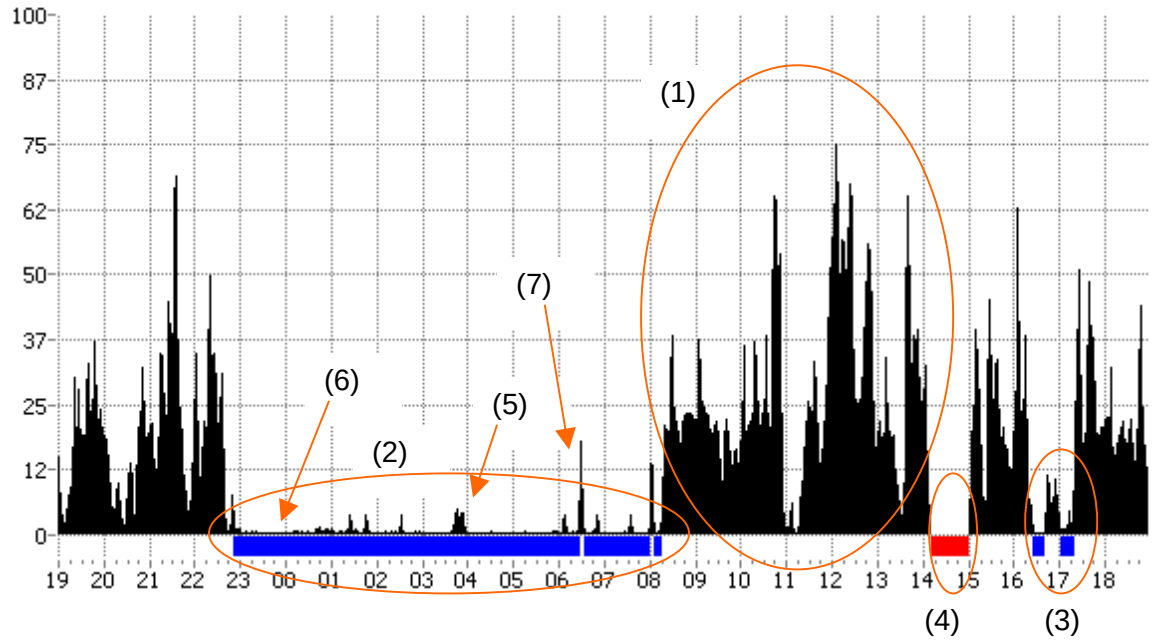


Figure 2. Activity curve depiction of a healthy person's sleep- wake rhythm.

One of a person's most important circadian rhythms is the variation of sleep and wakeful states, in other words the sleep-wake rhythm. A healthy person should naturally move sufficiently during the day and sleep peacefully during the night. Daytime activity curve values are large, and activity levels also fluctuate greatly (1). During the night, while the wrist unit's user is asleep and moves little because of this, the curve has markedly

smaller values than during the daytime (2). Activity levels also fluctuate little during sleep. Sleep time differs, for this reason, clearly from the daytime wakeful state. With a glance then, we can determine when a person is asleep or awake based on the amount of their movement. Regular events during the 24-hour period can also be observed with the help of the activity curve. For example a nap can be noticed as a short period of little movement in the afternoon (3). The user may be in the habit of taking a daily stroll at a certain time of day during which the wrist unit is out of signal range. There is a break in the activity curve at this time (4).

During sleep time a person also moves a little from time to time. Sleep time movement can be seen as low activity (5), which is, however, markedly smaller than that during this person's wakeful time. During deep sleep, a person is usually still, and their activity curve can show zero (6). Nighttime awakenings can be seen as periods of high activity during night hours (7). Good sleep should be sufficiently long, regular, continuous, and should include periods of deep sleep.

3. USE OF THE ACTITITY CURVE IN CARE WORK

Many changes in a person's well being, functional ability, and state of health are reflected onto their sleep-wake patterns, sleep, or wakeful time movement activity. Activity curves are useful in health care for two purposes:

1. **Evaluating changes and probable developments in well being, as well as**
2. **Follow up of treatment**

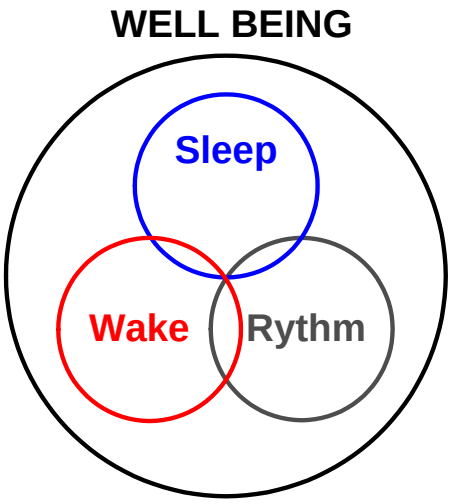
Changes in well being can be seen and effects of treatment can be evaluated by observing and analysing SWR patterns (Sleep, Wake, and Rhythm).

1. **SLEEP**

   Characterised by: awakenings, length of sleep, regularity, sleep quality, and where sleep time is situated during a 24-hour period.
2. **WAKE**

   Characterised by the level of activity during daytime hours.
3. **RYTHM, i.e. the alteration of sleep and wakefulness**

   Characterised by the ratio of day and night time activity.

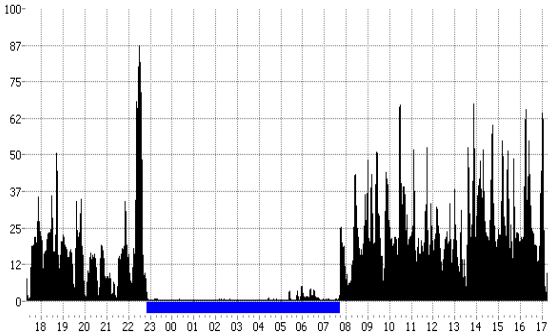


SWR patterns are significantly related to one's health. Sleep, wakefulness, and the alteration of these two i.e. circadian rhythm depict health independently, but are also closely connected to each other. A change in sleep often affects circadian rhythm as well as the wakeful state. A poorly slept night, for example, may cause sleepiness during the day and thus also a change in rhythm.

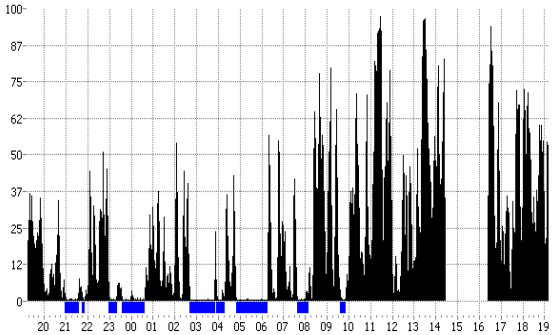
The following diagrams depict good and poor situations for each pattern.

1. **SLEEP**: awakenings, sleep time, regularity, and the time where sleep situates during a 24-hour period.

   The blue line depicts sleep time estimated on the basis of the curve.

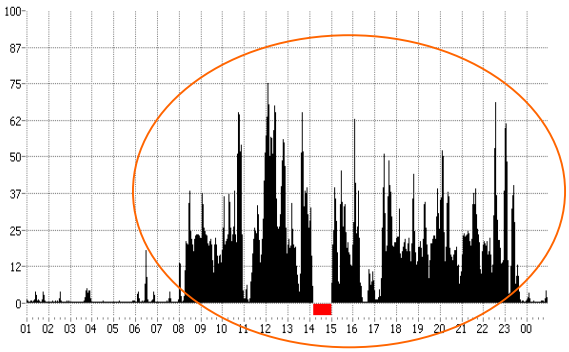


Good sleep: sufficient in length, occurs during night hours, no awakenings, several periods of deep sleep.

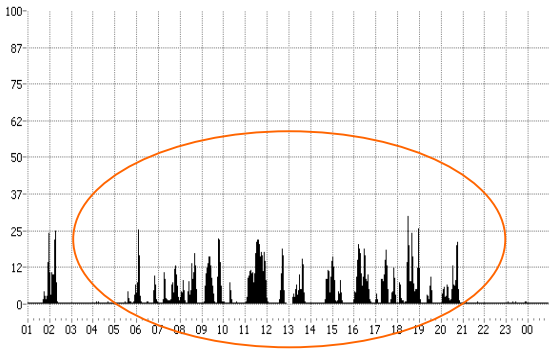


Poor sleep: several awakenings, long periods of wakeful time during night hours, the duration of sleep is short and fragmented.

2. **WAKE**: the level of daytime activity



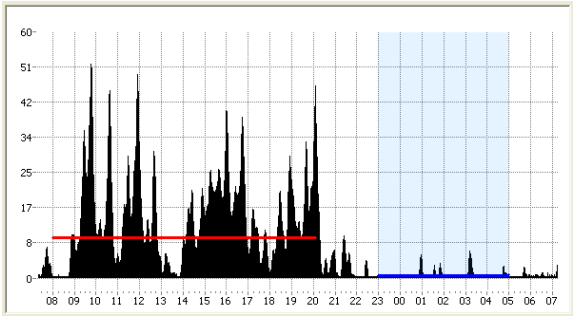
Good daytime activity: physically active with periodic rest breaks, outside in the afternoon (red line).



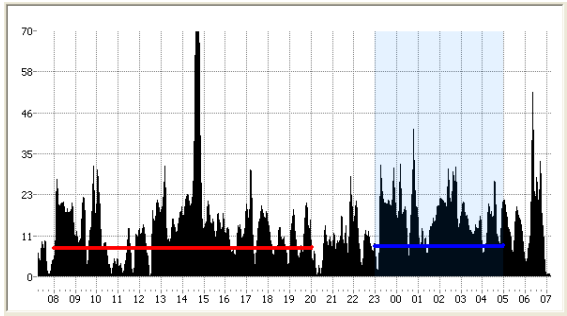
Poor daytime activity: low physical activity and also rests frequently during the day

3. **RHYTHM**: The relationship between night and daytime activity

   In these diagrams the blue line depicts average nighttime activity and the red line average daytime activity



Good rhythm: night and daytime activity levels differ markedly.



Poor rhythm: night and daytime activity levels are similar.

The efficient use of the activity curve in health care includes the following work stages:

- Observation (see chapter 4)
    - familiarization with customer and curve
- Activity curve SWR-analysis (see chapters 5-7)
    - examination of curve patterns and conclusions
- Reporting (see chapter 8)
    - notes and documentation
- Action
    - actual care

4. REASONS FOR CHANGES IN SLEEP-WAKE RHYTHM

The activity signal depicts changes in the health and well being of elderly people because these often cause a decrease in the level of daytime physical activity and otherwise restlessness, confusion, disruptions in night time sleep, and changes in daytime rhythm which can be seen on the activity curve.

Examples of reasons, which cause changes in circadian rhythm, are

- Sleep disorders:
  - fragmented sleep
  - problems falling asleep
  - morning awakenings
  - sleep apnea
  - restless legs
  - delayed or advanced sleep period
- Symptoms and illnesses that have an adverse effect on circadian rhythm and sleep:
  - confusion
  - blood circulation problems of the brain and limbs
  - Parkinson's disease
  - Alzheimer's disease and other dementia
  - other neurological disorders
  - back and joint pain and other skeletal or muscular illnesses and symptoms
  - heartburn and other stomach symptoms
  - night time chest pain
  - cardiac insufficiency
  - asthma or chronic bronchitis
  - urinary tract infections, incontinency
- Other temporary factors:
  - excessive use of coffee, tea, or alcohol
  - medication, especially sleeping pills (others: some heart and blood pressure medication as well as asthma medication and cortisone treatment)
  - excessive smoking
  - excessively long daytime naps
  - lying in bed waiting for sleep
  - lighted sleeping environment, noise
  - insufficient physical activity during the daytime
  - emotional reasons
  - anxiety
  - sadness and depression

The circadian rhythm of elderly people has characteristics common to older age. The necessary duration of sleep changes little with age, but sleep becomes lighter, fragmented, and diverse in quality as a person ages. Older people awaken more frequently than younger people. This results in decreased daytime vitality and fatigue. Elderly people also take more frequent naps. Elderly people retire to bed at an early hour and thus awaken at an early hour. Sleep difficulties increase with age so sleep medication is common.

5. GETTING TO KNOW THE ACTIVITY CURVE

Prior to familiarization with the activity curve itself, it is important to understand the customer's general information, state of health, functional ability, as well as other details, which can have an effect on the customer's activity curve.

Familiarization: general

Choose your preferred customer's activity curve post analysis window (figure 6). Initially a 4 days screen size can be chosen (1) to gain a general conception of the person's circadian rhythm. You can adjust the smoothing to its maximum value (2) and graph settings can be chosen so that only the line depicting midnight can be seen on the graph (3). This simplifies perception of the overview of a customer's activity curve.

Additional information: Curve smoothing is done by calculating the average of several surrounding points, each depicting one minute of activity. The stronger the smoothing, the more the adjacent surrounding activity affects the activity value of the moment in question. The smoothing only affects the displayed curve. Information is always stored in its most accurate form without smoothing. Smoothing eliminates details from the graph, but can clarify its main characteristics. The longer the duration of the graph being viewed on screen, the bigger the smoothing value should be used. When viewing a graph of shorter duration e.g. 6hr- 1 day, it is good to use a small smoothing value so that details will still be discernable.

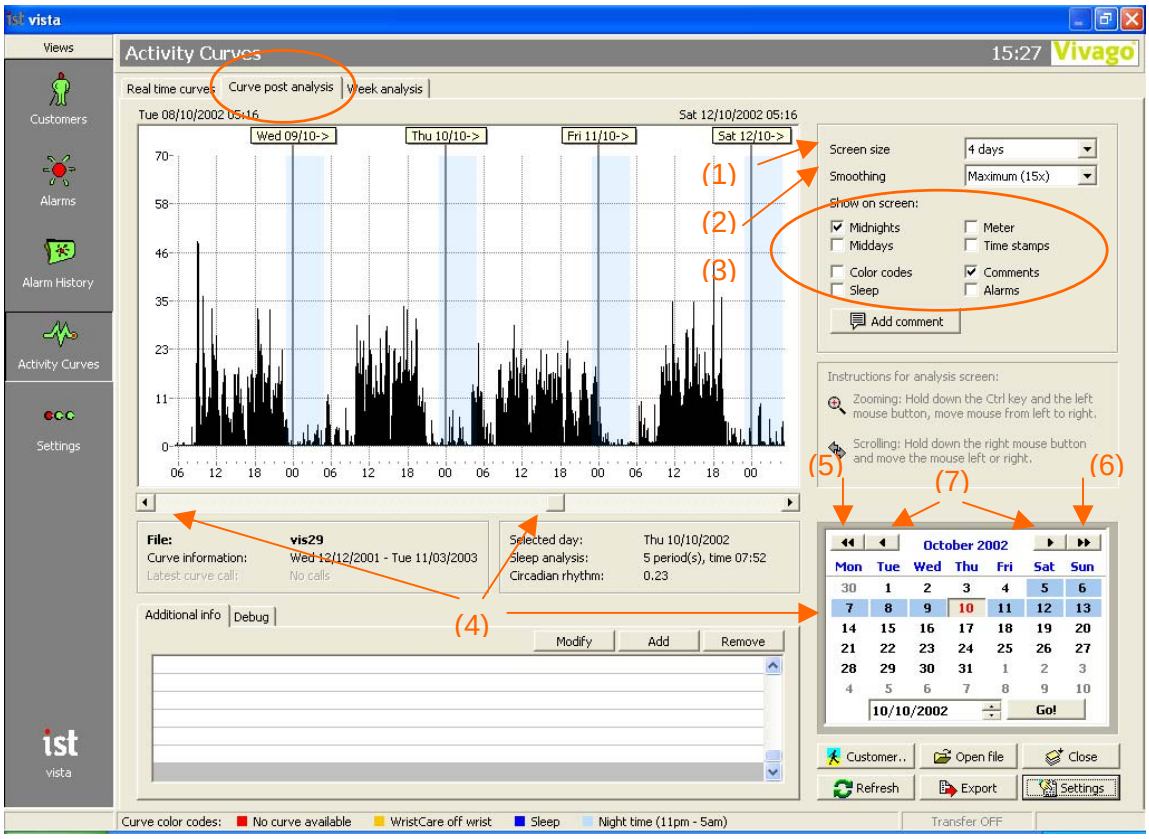


Figure 6. Post analysis of curves

You can scroll the curve visible on your screen by using the scroll bar underneath it and by using the calendar (4) on the right side of the screen. The curve screen always contains a maximum of nine days of data that can be viewed with the scroll bar. The blue coloured days on the calendar indicate which days have been selected for viewing. The red day indicates the day that is currently showing in the middle of the screen. First choose the time period from the calendar and scroll back and forth with the help of the

scroll bar. When you are viewing a customer's curve for the first time, you can go to the beginning of his/her data by pressing the double arrow button on the calendar (5). Go to the end of the data by pressing the double arrow to the right (6). The arrow button (7) enables you to change calendar months.

The blue field in the background of the activity curve analysis window is always between 11pm and 5am. This coloured field helps to easily distinguish the position of nighttime on the screen and where the person's own sleep rhythm situates during a 24-hour period.

Begin by viewing curves from a time period that you want to compare to the current situation. Always observe a period of at least one week, preferably several weeks. While browsing through the curves note the following factors:

- General circadian rhythm: can you differentiate daytime from night, is sleep time taking place during nighttime hours, and is rhythm regular?
- The average level of daytime activity
- The average level of night time activity

Make a record of a typical time period, obvious changes, and other known events that have had an effect on the activity curve. See the chapter on reporting for more detailed instructions on how to make a report from the curves.

Familiarization: a more detailed analysis

When you have a general conception of the person's circadian rhythm, choose a shorter time window for your screen (figure 7), by setting one day for the size of your display. Choose normal (1) for the smoothing value so that you can more easily differentiate details. Select midnight, midday, and the meter on your screen. Choose the colour codes and the sleep display (2).

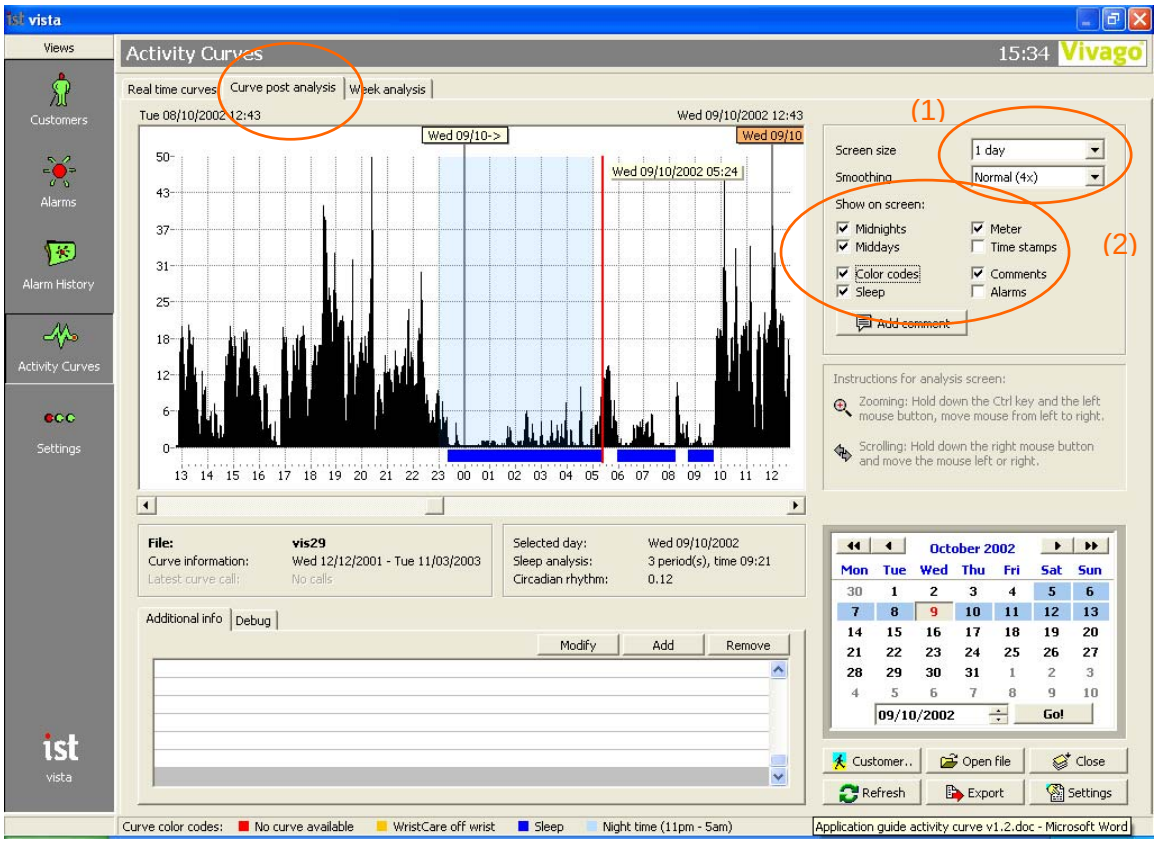


Figure 7. Observing one 24 hour period

Choose for observation those 24-hour periods, which you have determined to be typical, poor, and good for your customer. Observe the following patterns:

- The placement of sleep time within the 24 hour period, falling asleep and waking up times
- The duration of sleep and number of sleep periods
- The number of awakenings, their duration, and their position during night time
- Movement during sleep, are there periods of deep sleep
- Daytime activity variation: maximum value for activity
- Daytime rest periods, their position, and duration

See the separate chapter on sleep analysis for instructions on how to use the program for observing sleep patterns.

Make a record of a typical time period, obvious changes, and other known events that have had an effect on the activity curve. See the chapter on reporting for more detailed instructions on how to make a report from the curves.

Familiarization: long term analysis

When you have become familiar with individual days, you can observe typical characteristics of a longer time period by choosing the week analysis sheet (figure 8).

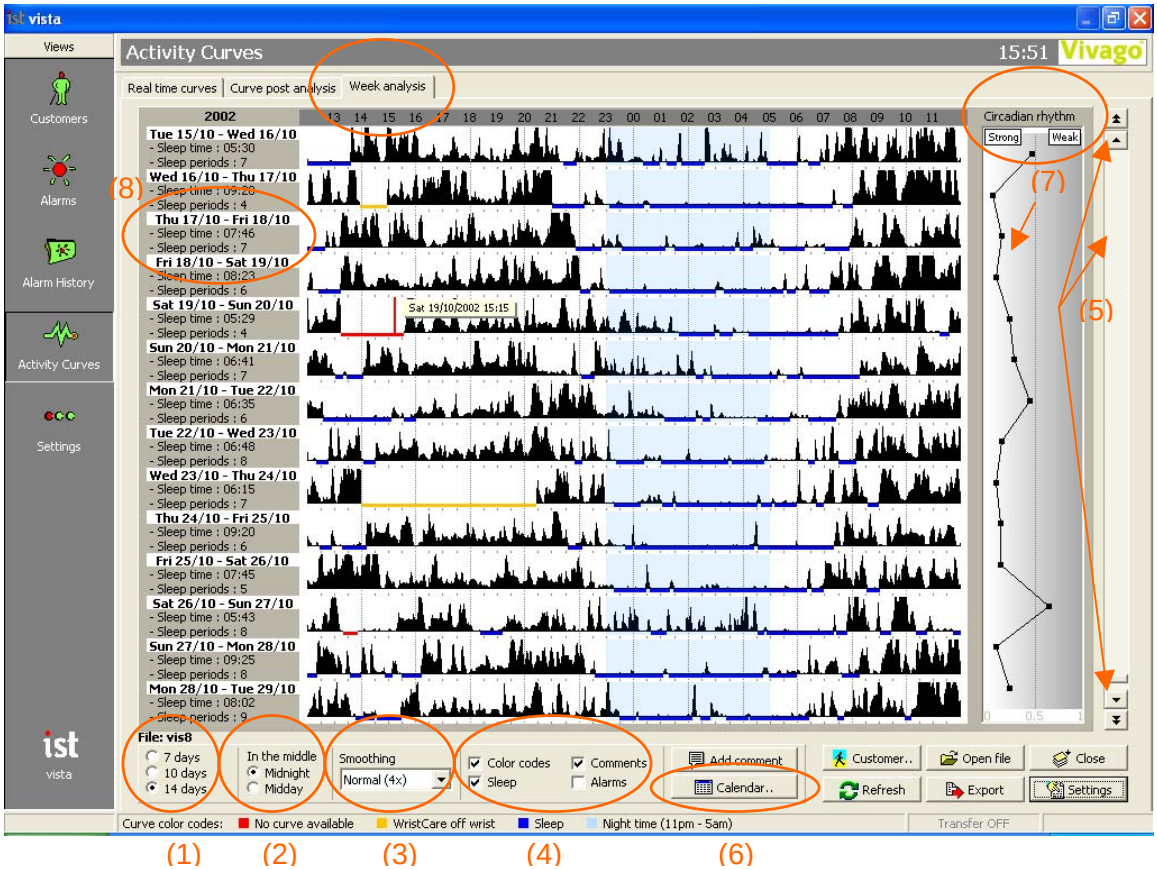


Figure 8. Week analysis

First choose the 14-day display (1) and place midnight in the middle of the screen (2). Use normal smoothing (3). Choose the colour codes and sleep display, hide comments and alarms from the screen (4). You can scroll the curve using the scroll bar at the right hand side of the screen (5). The double arrow moves you one full screen back or

forward, in this case 14 days. You can also use the calendar to move around in time (6) just as in the post analysis window. By double clicking your mouse on a curve on the display, you can switch to the post analysis mode for more detail of the chosen period.

The purpose of this display is to aid in the comparison of 24-hour periods so that changes can be detected. Consecutive 24-hour periods are one below the other, the top one being the oldest. The screen will display 7, 10, or 14 days according to your choice (1). Each row shows 24 hours of data so that your choice of either midnight or midday is in the middle (2). When you want to compare nights to one another, it is easier to place midnight in to middle, and when you want to compare days, place midday in to middle.

It is especially beneficial to use colour codes on the weekly analysis display. With their help you can see regularly occurring events that stem from the user's lifestyle. For example, if the user often removes the wrist unit during the night, it can be seen as a recurring yellow bar during the night under the curve. Similarly, the user's moving out of signal range, for example, during walks outside would be seen as a red bar. When necessary, the situation can be commented on, by, for example, asking the customer to keep the wrist unit on during the night as well.

On the right hand side of the display there is a curve, which depicts the user's circadian rhythm (7). The curve has been calculated for each day by dividing average daytime activity by average nighttime activity. The better a person's circadian rhythm is, the closer to zero and to the left side of the scale the curve is. If nighttime activity is the same or even greater than daytime activity, the circadian rhythm will have a value of one or more. The curve will then be close to the right hand side of the scale and rhythm is obviously poor. When you move the mouse pointer on top of a point on the curve, the calculated numerical value for circadian rhythm will be shown. See the separate chapter on circadian rhythm.

In the field (8) on the left hand side of the display, calculated sleep time and the number of sleep periods for the 24-hour period in question can be seen. See the separate chapter on sleep analysis for instructions on how to use the program for observing sleep.

Begin by viewing curves from a time period that you want to compare to the current situation. While browsing through the curves on the weekly analysis display take special note of the following things:

- What is the average circadian rhythm value, does it vary? Are certain days, like weekends better than others?
- Are there regularly recurring events such as walking outdoors and does the user keep the wrist unit on?
- Sleep and its regularity. Is calculated sleep time short, or is it especially abundant, is average sleep time normal, does it situate in night time hours, are there many sleep periods, is the sleep pattern regular or is there a lot of diversity, is there sleep during the daytime?
- Are there abrupt changes taking place within one or two days to circadian rhythm or sleep characteristics?
- Are there gradual changes taking place over the period of several days or weeks to circadian rhythm or sleep characteristics?

Make a record of a typical time period, obvious changes, and other known events that have had an effect on the activity curve. See the chapter on reporting for more detailed instructions on how to make a report from the curves.

Summary

	Screen settings	**Observable patterns**
General view	Curve post analysis window Screen size: 4 days Maximum smoothing Show on screen - Midnights	General circadian rhythm Average: - daytime activity - nighttime activity
Detailed analysis	Curve post analysis window Screen size: 1 day Normal smoothing Show on screen - Midnights - Middays - Meter - Colour codes - Sleep	24-hour patterns: - awakenings - sleep time - situation of sleep in night time - phases of deep sleep - maximum day time activity - low activity periods during day time
Long term analysis	Week analysis window 14 days view Midnight in the middle Normal smoothing Show on screen - Colour codes - Sleep	Circadian rhythm and its changes - average value - fluctuation Recurring events - moving out of range, walking outside - wrist unit usage rate Sleep and changes in sleep pattern - regularity of sleep - sleep time, number of sleep periods, situation of sleep in the day Slow and fast changes in the circadian patterns

6. SLEEP ANALYSIS

6.1 The normal structure of sleep

There are five stages of sleep, four of which form a continuum towards deep sleep. The first and second stages are light sleep and the third and fourth are deep sleep during which a person is normally quite motionless. The fifth stage is REM (Rapid Eye Movement), which usually appears after the first period of deep sleep about 1 hour after falling asleep. It is typically accompanied by dreaming.

Figure 9 is an example of the activity curve's depiction of normal sleep. Upon falling asleep the activity curve drops steeply indicating the beginning of sleep (1). If sleep quality is good, the curve remains at a very low value for one or two hours and the first period of deep sleep has been successful (2). Accumulated sleep deprivation accelerates the appearance of deep sleep. During the following REM sleep occasional slight awakenings or movements can render higher activity within an otherwise low curve (3). Approaching twilight, the amount of deep sleep usually decreases and restlessness associated with REM increases. This is apparent on the curve (4). The fluctuation between shallow and deep sleep becomes slower towards morning.

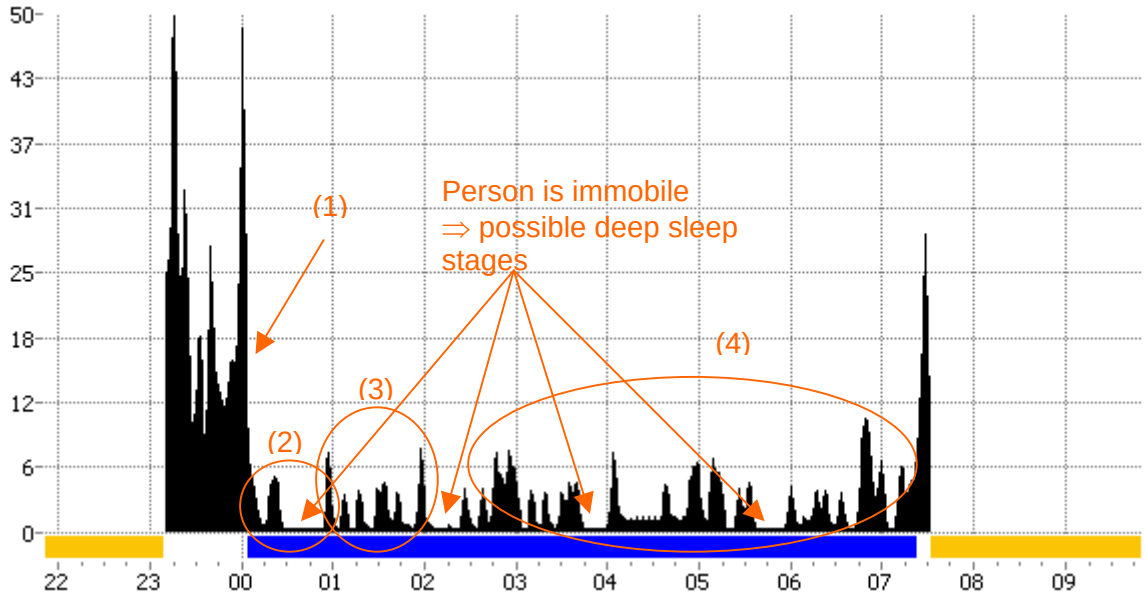


Figure 9. The structure of sleep

The sufficiency of deep sleep can often be determined from the activity curve. Evaluation should be made by observing several consecutive nights. An isolated night may contain disturbances and does not necessarily reflect the typical situation. The amount of deep sleep can be considered sufficient if, especially during the first hours of the night, there is a very low, almost zero point curve for two to three hours. During a normal eight-hour sleep period, a person only requires one generous hour of deep sleep and two hours of REM to stay alert and functional. Three hours of sleep is insufficient for even a very efficient sleeper because the other phases of sleep around deep sleep are also necessary to complete sleep stages. There are people who successfully manage this in six hours. Various disturbances and individual characteristics, however, can greatly increase the necessary duration of sleep.

The rising of the activity curve to a level close to daytime activity for several minutes is a sign of awakening. If a person experiences significant daytime fatigue, there is reason to evaluate the quality of sleep with the help of the curve and try to isolate disturbing factors.

6.2 Method and settings

The Vista program can automatically calculate and show an estimate of the customer's sleep time. The calculation of sleep time is based on the threshold value method (figure 10). When the measured activity is below the adjusted threshold value (6.00 in example) for a set time (15 min), the program assumes the person is asleep. Correspondingly, awakening is assumed when activity is above the same threshold value for a sufficient time (5 min). The settings can be changed using the "Settings" button (1). You can use either predefined settings (2) or make your own adjustment. Calculated sleep time is displayed under the curve with the blue bar (3). The information screen (4) allows you to view the calculated number of sleep periods, that is, the number of separate blue bars within the selected day, and total sleep time as a sum of these. In addition, the information screen shows the calculated circadian rhythm for the selected 24-hour period (see the chapter on circadian rhythm).

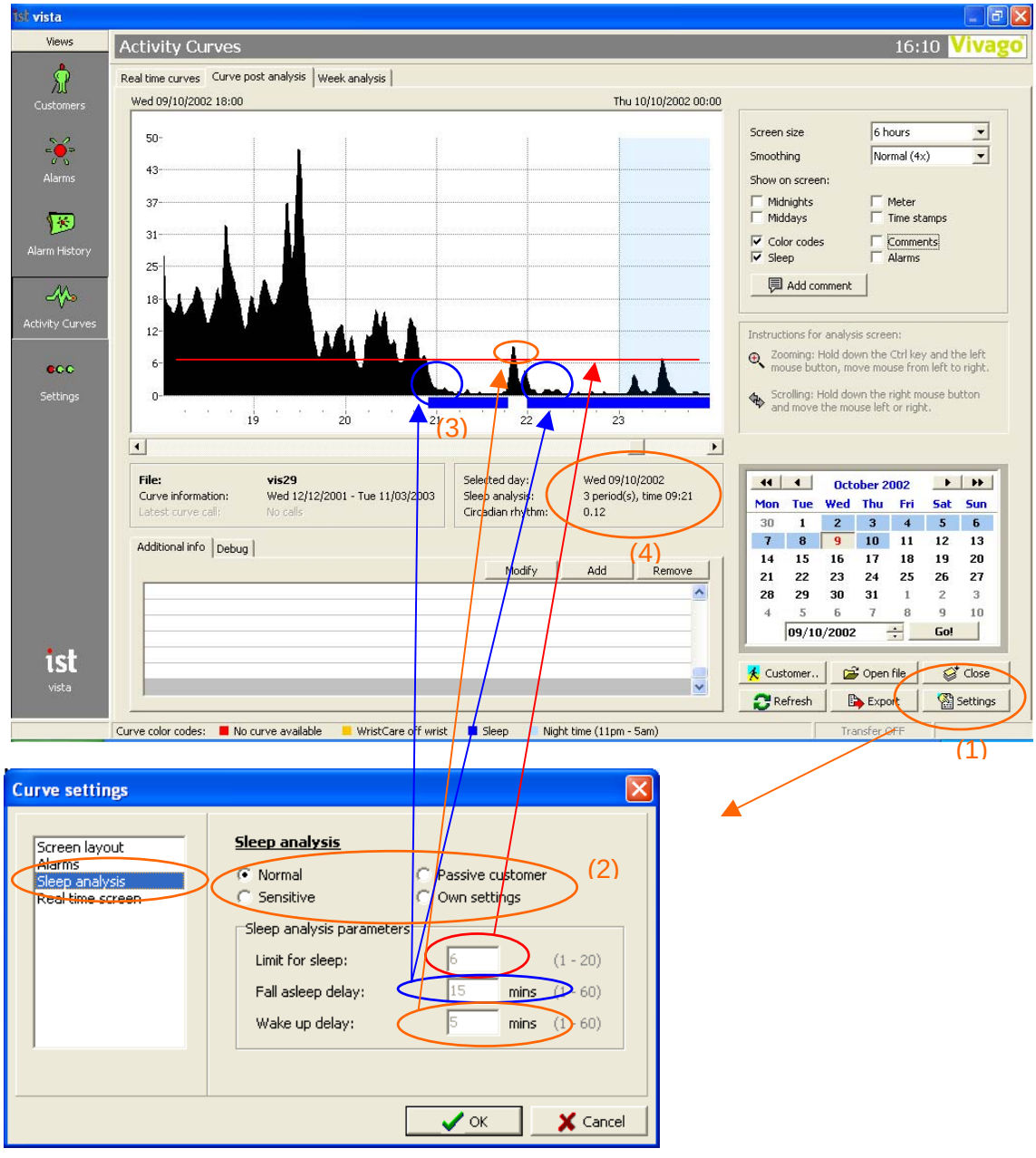


Figure 10. Sleep analysis settings

6.3 Accuracy of sleep analysis and adjustment

Automatic sleep analysis is an estimate and its accuracy is 80%. Typically the analysis gives sleep times 30-70 minutes longer than actual times because situations during which a person is awake but does not move for some other reason are also interpreted as sleep. **Elderly people having poor functional ability may have very low daytime activity. In this case the sleep analysis interprets wakefulness, but low activity as sleep. The calculated and displayed sleep times are markedly longer than in actuality.** There are also people suffering from different types of sleep disorders for whom the analysis will produce shorter than actual sleep time, because they may move about restlessly during sleep, and this is interpreted as wakefulness.

The sleep limit estimated on the basis of movement activity is unique to the individual, but for most people, who have normal functional ability, and who don't suffer from sleep disorders, default values for settings: limit for sleep 6.00, fall asleep delay 15min, and wake up delay 3min render good accuracy.

For elderly people who have low functional ability and who's default values produce markedly higher values than in actual experience, the sleep limit should be decreased (e.g. 3.00) and the fall asleep delay increased to (e.g. 20 min).

If a person has a sleep disorder and sleeps restlessly, the sleep limit can be increased (e.g. 10.00) and the wake up delay can be increased (e.g. 6min).

6.4 Use of sleep analysis

The purpose of the automatic sleep analysis is to help to observe the states of sleep and wakefulness. Graphic presentation makes it easier to notice abnormal sleep and observe long-term changes in sleep patterns.

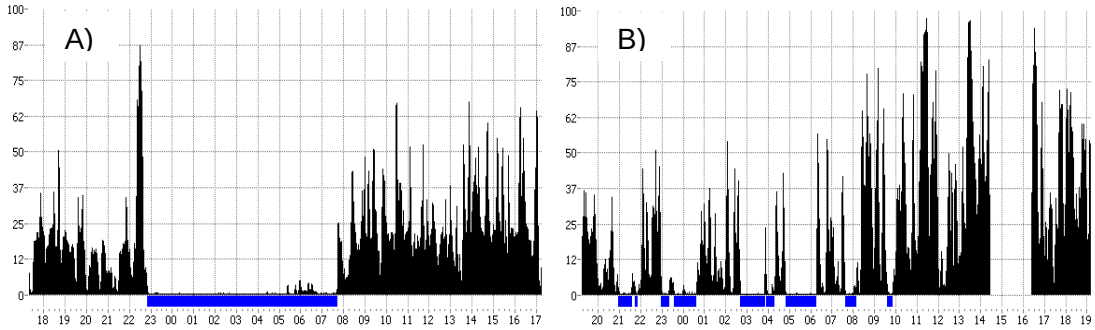


Figure 11. A) normal sleep b) disturbed sleep

The ideal situation is shown in figure11 A), where there is one consecutive sleep period of about 9 hours. Sleep takes place during nighttime hours between 23:00-8:00, and the user is awake during the daytime. The blue bar depicting sleep is continuous and sufficiently long.

Figure 11 B) depicts an abnormal situation. Sleep time is broken into several phases due to frequent awakenings. The deviation from normal sleep is easily detected from the broken blue bar under the graph.

Long-term changes are easily observed with the help of the week analysis screen. Figures 12 and 13 show examples of change in sleep duration.

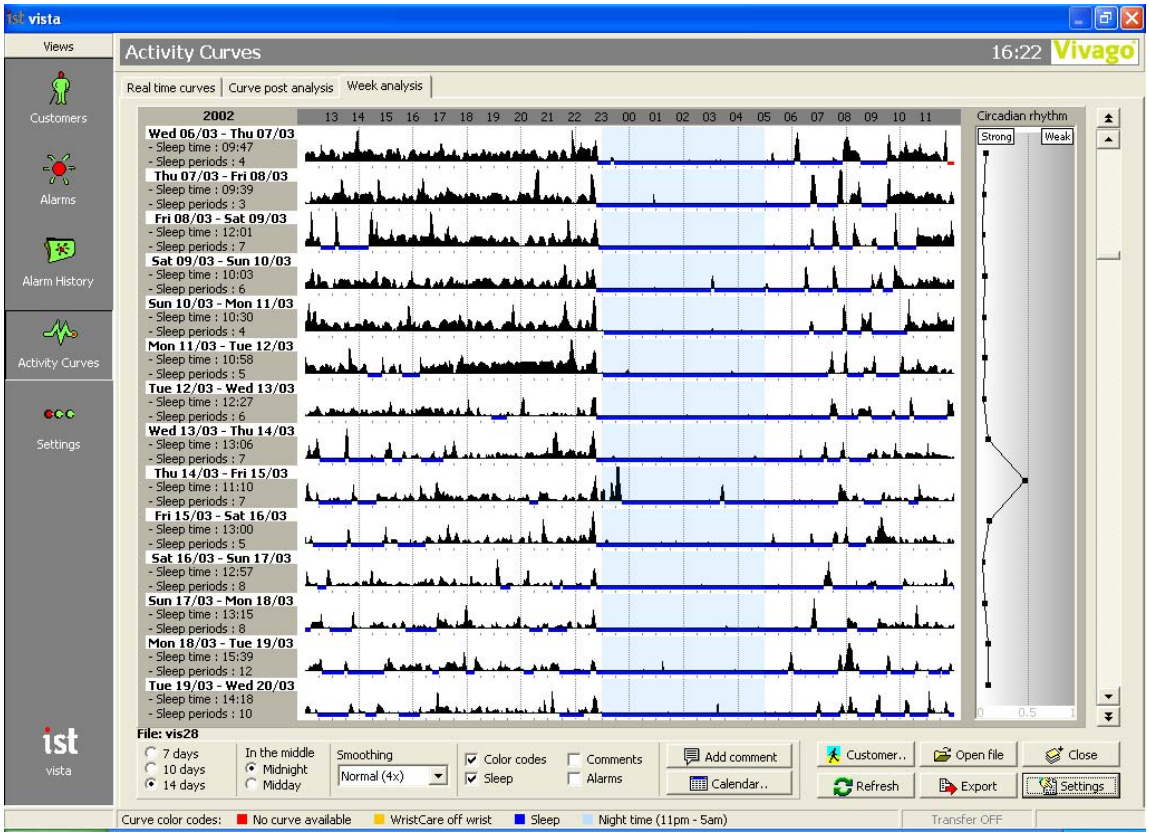


Figure 12. Increase in sleep duration (and a single daytime rhythm change 14.3-15.3)

Figure 12 shows that sleep duration has markedly increased beginning 12.3. This is particularly evident during afternoon hours. Prior to 12.3. the person slept in the afternoon only on 8.3. and 11.3. Starting on 12.3, however, s/he sleeps every afternoon for several hours. Calculated sleep time increases by an average of about two hours. This may be a sign of increased fatigue the reason for which should be investigated. The increase of fatigue can also be seen as a decrease in daytime activity level beginning on12.3.

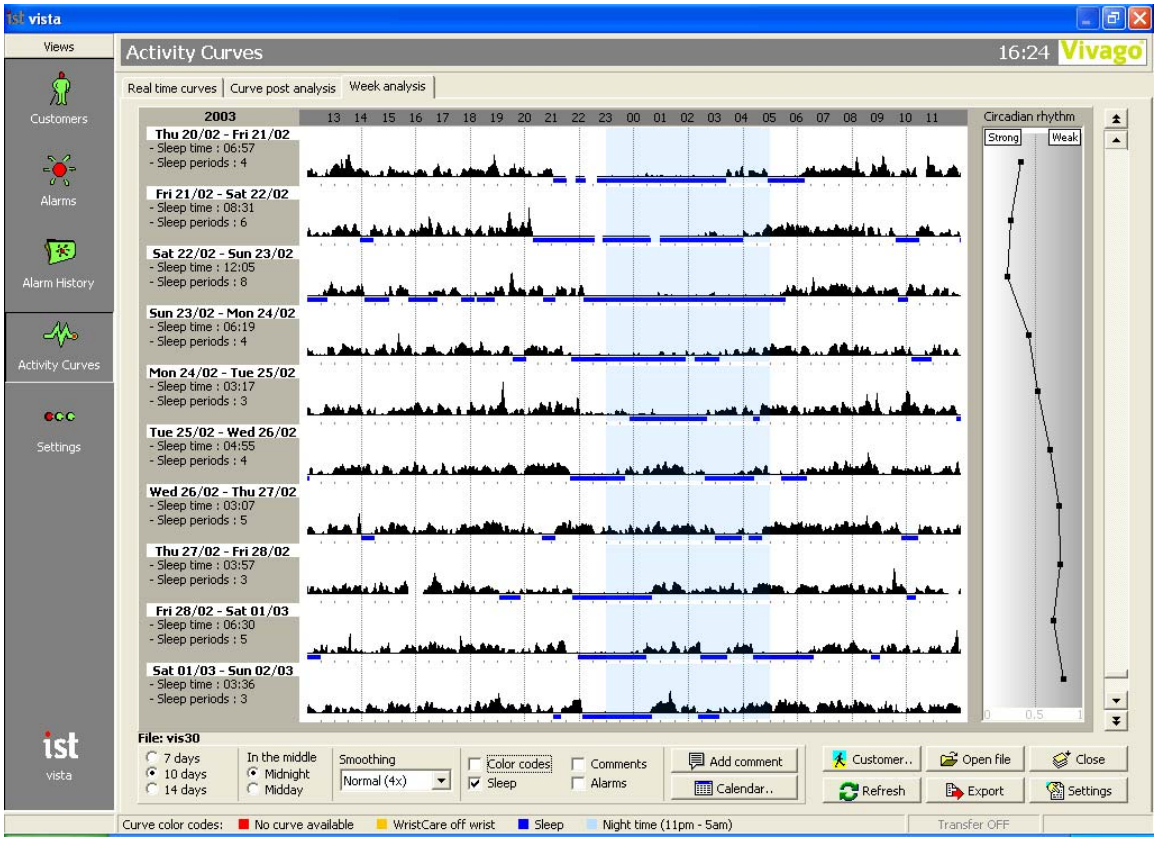


Figure 13. The deterioration and fragmentation of sleep (also the weakening of circadian rhythm)

Sleep duration of the person in figure 13 decreases markedly and nighttime wakefulness increases markedly beginning on 25.2. Earlier, sleep time has been fairly tied to nighttime hours, and has been quite consecutive. On 25.2. calculated sleep duration decreases by about two hours, the user seems to sleep only at the beginning of the night, and on 26.2, not even that.

An obvious deterioration in sleep can be the sign of a problem in well being. The person's physical condition should be, reviewed to find the underlying reason. Deterioration in condition can also be seen as the weakening of circadian rhythm (see next chapter).

7. CIRCADIAN RHYTHM

7.1 Method

With the help of the activity curve, it is possible to observe a person's circadian i.e. sleep-wake rhythm. Circadian rhythm refers to the relationship between daytime and nighttime activity. Vista calculates and presents a value representing circadian rhythm for each 24-hour period (figure 14). The value is calculated from the curve by dividing average nighttime activity (NightActivity) by average daytime activity (DayActivity):

$$CircadianRhythm = \frac{NightActivity}{DayActivity} \quad .$$

Nighttime, from which average activity vale is calculated, is between 23:00-5:00 and it appears as the light blue area on the screen. Daytime is between 8:00-20:00. Circadian rhythm is always calculated by dividing nighttime activity by the activity of the previous day.

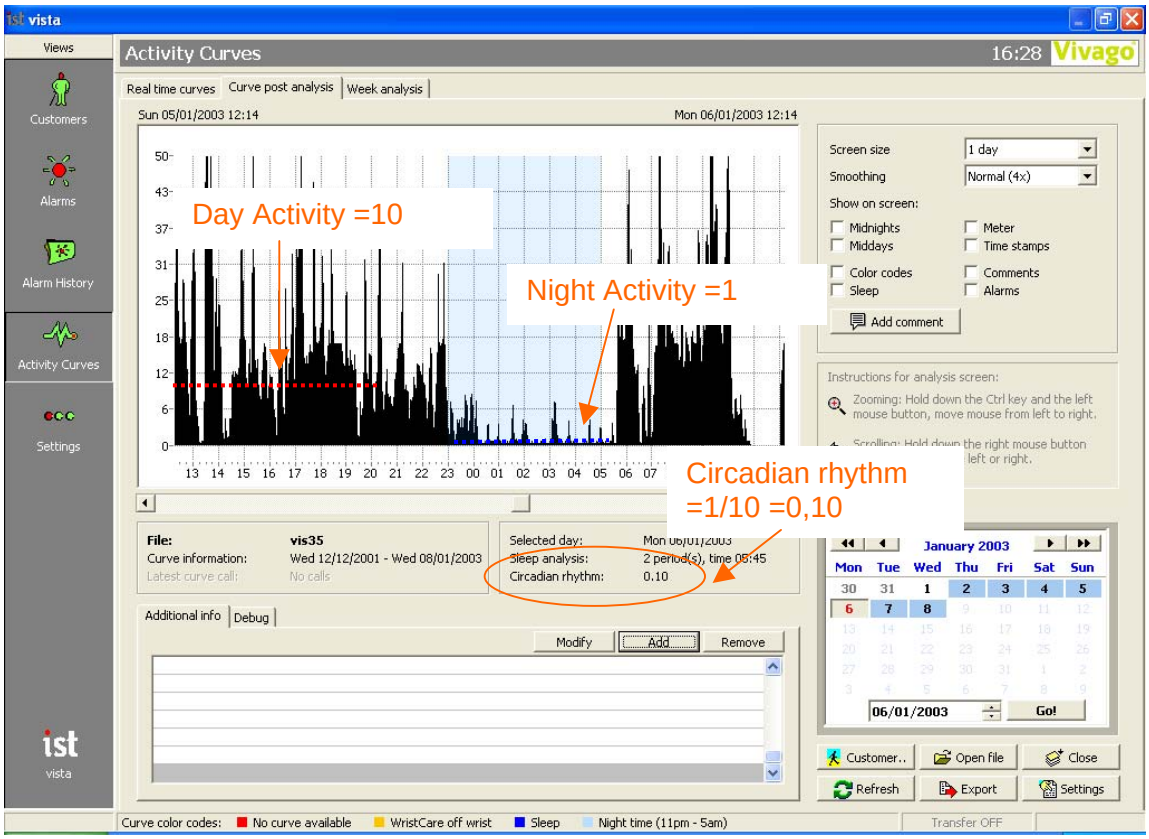


Figure 14. Circadian rhythm. Average nighttime activity ≈1 (blue dotted line) and average daytime activity≈10 (red dotted line), so circadian rhythm = 1/10 = ***0.1****. This is a strong rhythm.*

The calculated value for circadian rhythm represents the quality of sleep-wake rhythm. When the rhythm is strong, nighttime activity is minimal and daytime activity is great. In this case the circadian rhythm value is close to zero. When the rhythm is weak, nighttime activity is close to daytime activity. In this case the calculated value is close to or greater than 1.00. If the value is greater than one, the rhythm is reversed, that is, the person is more active during the nighttime than the daytime.

Circadian rhythm and changes in it are easier to observe on the week analysis screen (figure 15). There is a curve on the right edge of the screen, the points of which represent the circadian rhythm values for each day. By pointing to a curve point with your mouse, Vista will show the numerical value for circadian rhythm on that day (e.g. 0.23). If circadian rhythm is reversed, that is, nighttime activity (2) is greater than that in the daytime (3), then the corresponding point will be red. If several hours of activity data are missing for either night or daytime, for example if the user neglected to wear his/her wrist unit (4) or has been out of transmission range, then that days circadian rhythm cannot be reliably calculated. In this case the circadian rhythm curve has a gap (5).

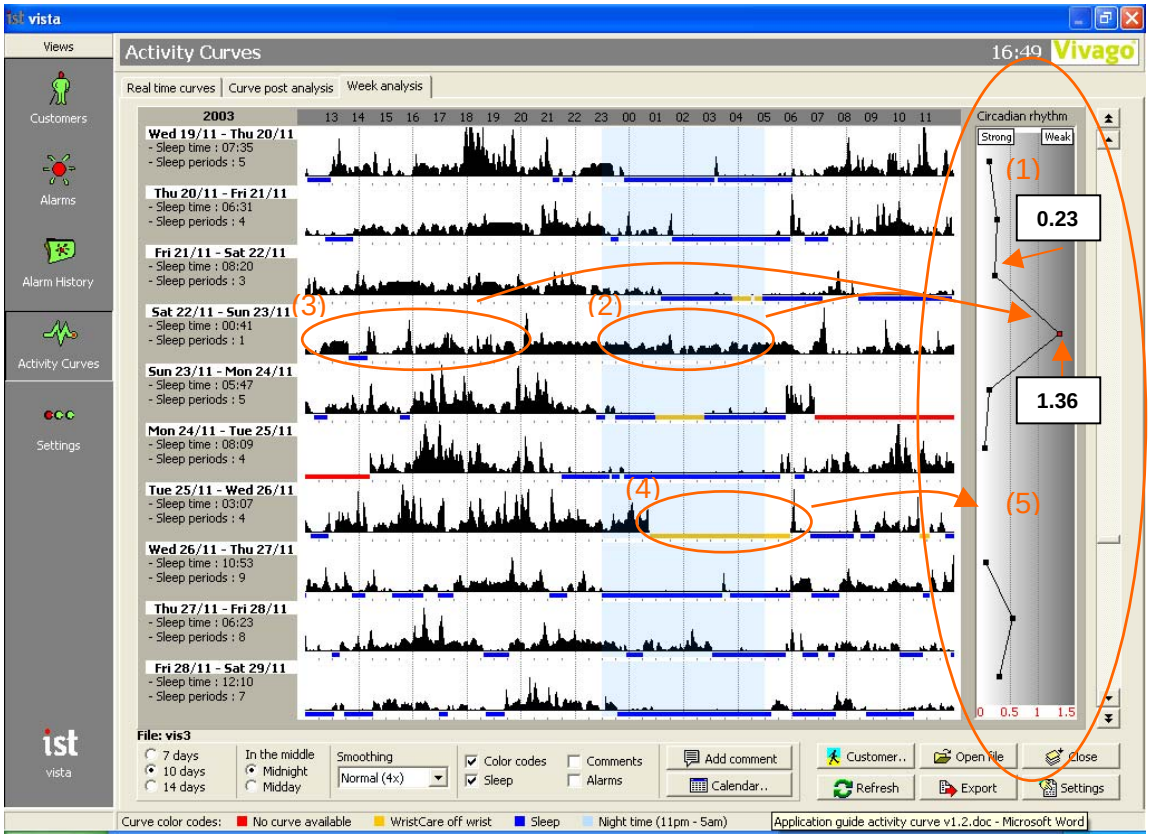


Figure 15. Circadian rhythm on the week analysis screen.

In figure 15 the person has hardly slept at all on the night between 22.11. and 23.11. His/her daytime activity is even greater than that of the nighttime. Because of this, the calculated circadian rhythm has a large value (1.36) and the curve moves toward the right edge during this period of 24 hours. Normally, his/her circadian rhythm is an average of 0.2. The deviating period is easily noticeable as a sharp turn to the right. A similar situation can be seen on 25. -26.11, when the user has taken off the wrist unit for the night. The night between 27. -28.11. is also more restless than normal and the circadian rhythm value is 0.54.

7.2 Intended use of circadian rhythm

By observing circadian rhythm and the curve depicting it, we can detect changes in a person's well being. With the help of a graphic presentation, it is easy to notice deviations from a normal state as well as slowly developing long-term changes.

Normally, when a person is well, she/he is physically active during the day and sleeps regularly during the night. The circadian rhythm is then close to 0 and the curve moves along the left edge of the scale. When a person's condition deteriorates, it may be seen as sleeplessness, nighttime awakening, sleep time deviating from night time hours, a decrease in daytime activity, or a combination of all of these simultaneously. Changes in a poor direction increase the calculated value of circadian rhythm and move its depicting

curve towards the right edge of the scale. Accordingly, when a person's condition improves, we can see that the circadian rhythm returns to normal and the curve moves back towards the left edge of the scale.

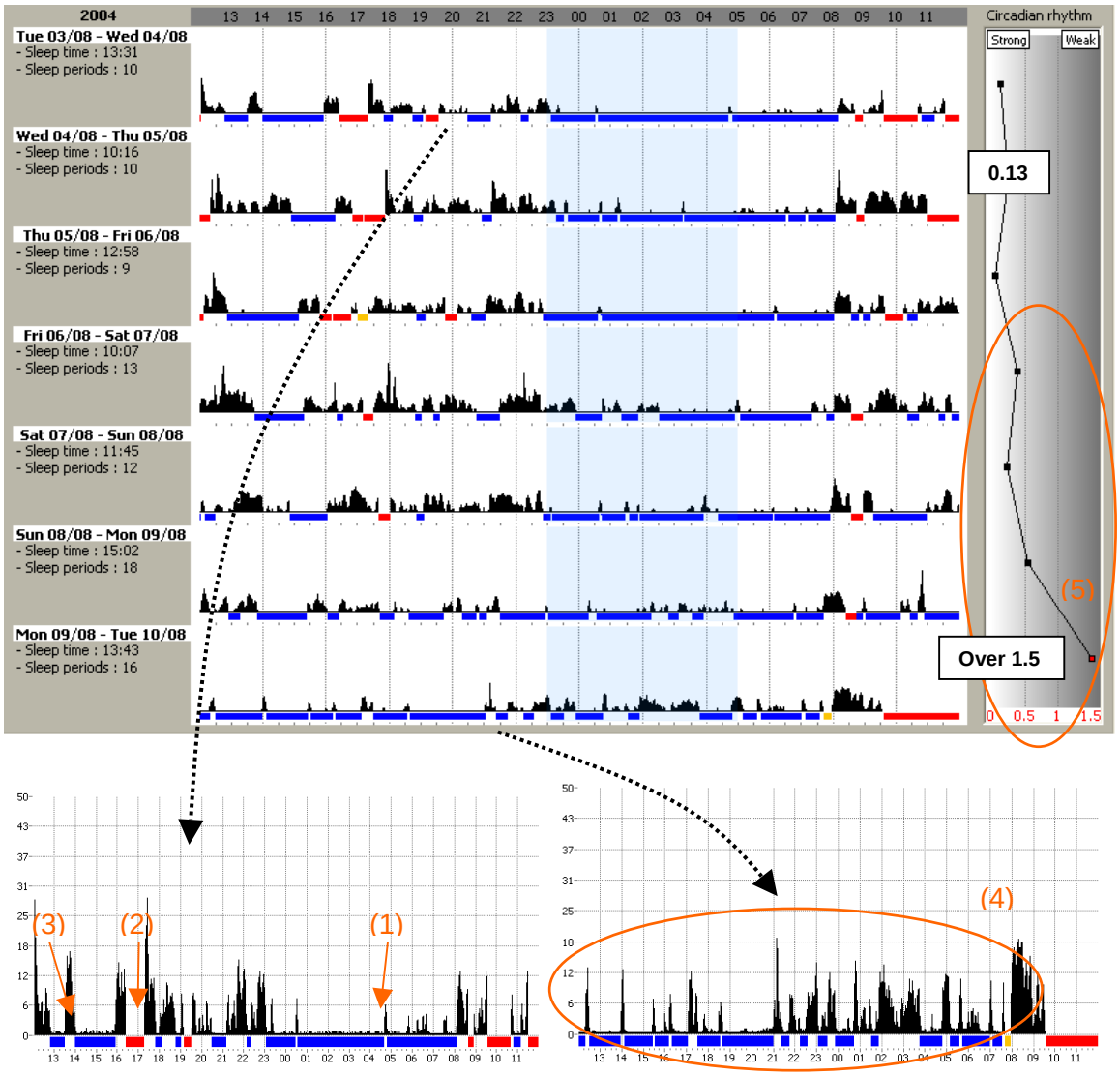


Figure 16. A rapid deterioration of circadian rhythm.

Figure 16 shows an example of the rapid deterioration of circadian rhythm. The user usually has a good circadian rhythm (0.13 on Thursday 4/8). She/he sleeps well, over 8 hours during the night (1). This person is physically active and outdoors often during the daytime, and for this reason the wrist unit it out of signal range a few times every day (2). She/he usually has an afternoon nap (3)

Beginning on Sunday 8.8. this person's circadian rhythm deteriorates markedly. Daytime activity level drops, outdoor activity halts, daytime naps increase in number and duration, and nighttime sleep deteriorates or becomes virtually nonexistent. On Monday and Tuesday this person's circadian rhythm is already reversed, that is, she/he is more active during Tuesday night than during the preceding day (4). The circadian rhythm value is 1.5. The change is obvious on the circadian rhythm curve (5).

Dramatic deterioration of circadian rhythm can be a sign of a problem in well being. The user's condition should be checked to find the source of the problem.

8. ANALYSIS OF WAKEFULNESS

With the aid of the activity curve we can observe a customer's physical activeness during wakeful hours. The higher the values on the activity curve, the more actively the person is moving. For the activity curve to reach its maximum value (100) the user must be vigorously active, for example doing an active sport activity or demanding physical labour. It is also beneficial to observe variation in activity level. Generally a person will be active for short periods at a time followed by rest periods during which calculated activity will have low values.

A person has good wakeful activity if his/her average value is markedly greater than the normal sleep limit (>6). In addition, activity should periodically have large values (>50), which are then followed by a period of lesser activity. Variation in activity during wakeful hours is usually a good characteristic.

Because the activity curve depicts physical performance during wakeful hours, by observing this pattern, changes in well being that have an effect on daytime vitality and energy level can be detected.

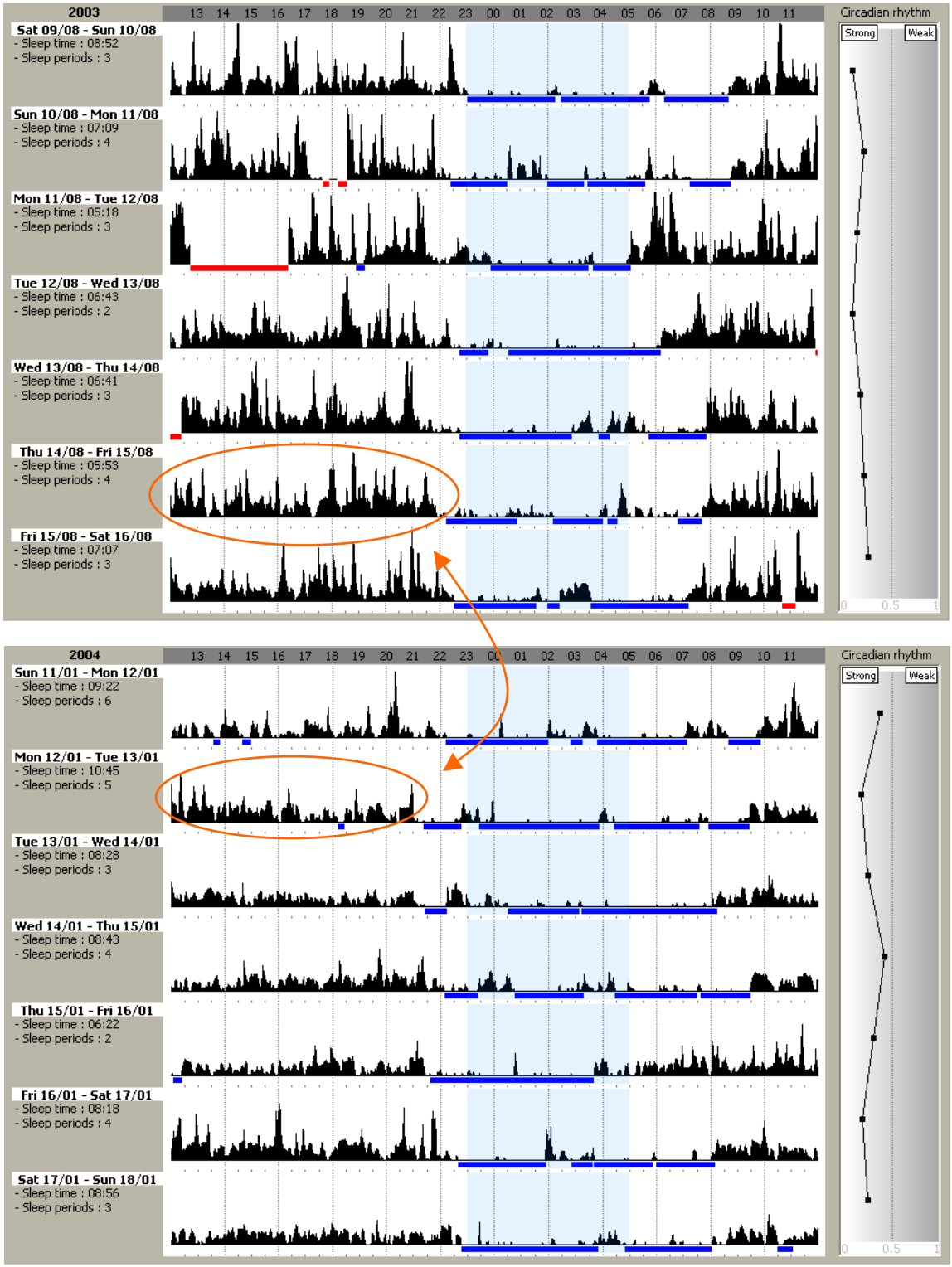

2003
13 14 15 16 17 18 19 20 21 22 23 00 01 02 03 04 05 06 07 08 09 10 11
Circadian rhythm
Strong
Weak
Sat 09/08 - Sun 10/08
- Sleep time : 08:52
- Sleep periods : 3
Sun 10/08 - Mon 11/08
- Sleep time : 07:09
- Sleep periods : 4
Mon 11/08 - Tue 12/08
- Sleep time : 05:18
- Sleep periods : 3
Tue 12/08 - Wed 13/08
- Sleep time : 06:43
- Sleep periods : 2
Wed 13/08 - Thu 14/08
- Sleep time : 06:41
- Sleep periods : 3
Thu 14/08 - Fri 15/08
- Sleep time : 05:53
- Sleep periods : 4
Fri 15/08 - Sat 16/08
- Sleep time : 07:07
- Sleep periods : 3
0 0.5 1
2004
13 14 15 16 17 18 19 20 21 22 23 00 01 02 03 04 05 06 07 08 09 10 11
Circadian rhythm
Strong
Weak
Sun 11/01 - Mon 12/01
- Sleep time : 09:22
- Sleep periods : 6
Mon 12/01 - Tue 13/01
- Sleep time : 10:45
- Sleep periods : 5
Tue 13/01 - Wed 14/01
- Sleep time : 08:28
- Sleep periods : 3
Wed 14/01 - Thu 15/01
- Sleep time : 08:43
- Sleep periods : 4
Thu 15/01 - Fri 16/01
- Sleep time : 06:22
- Sleep periods : 2
Fri 16/01 - Sat 17/01
- Sleep time : 08:18
- Sleep periods : 4
Sat 17/01 - Sun 18/01
- Sleep time : 08:56
- Sleep periods : 3
0 0.5 1

Figure 17. The gradual change of daytime activity in an adverse direction. The top figure shows the person's 7-day activity for August and the lower, six months later for February. The most prominent change is the marked decline in daytime activity, which is also reflected in the circadian rhythm. There has been no sudden change in the person's state of health, but rather a gradual deterioration of his/her physical performance.

9. REPORTING

After viewing a person's activity curve, analysis, conclusions, and appropriate actions, it is beneficial to also record observations and completed actions. In the long range, a great deal of curve information amounting to months or even years can be accumulated. Often only a part of this accumulated information contains changes or events of interest that are necessary to report separately to, for example, the client or to care giving personnel or the residing doctor.

The Vista program allows for the recording of comments, and supplementary information as a part of the curve database. Curve information can be exported from the program and be attached as part of other customer documentation in various ways, or can, for example, be made into a separate report using a regular word processing program.

9.1 Comments and additional information

The Vista program automatically records each customer's curves and resulting alarms. Comments added to the curve and observations written in the additional information field can also be recorded in the same database. When transferring or copying curve information, this information will also be transferred.

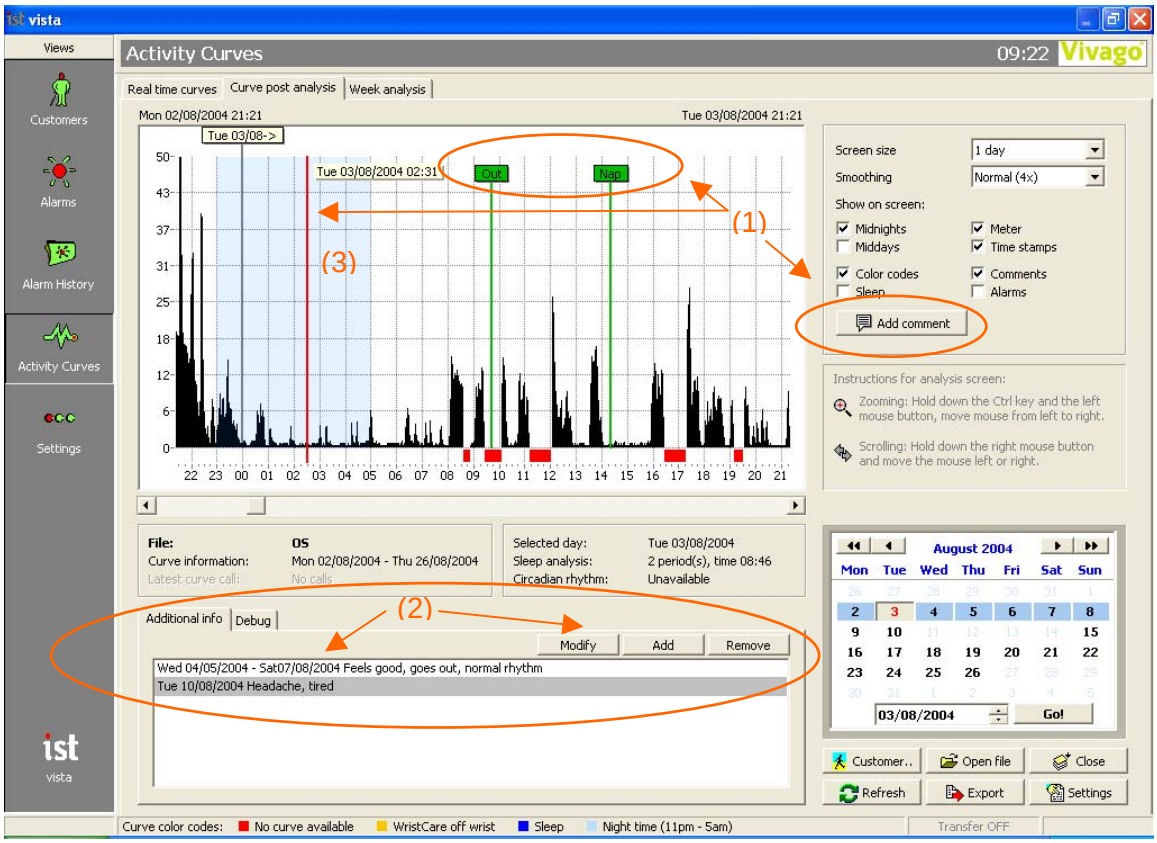


Figure 18. Adding comments and additional information to curve data.

Figure 18 shows an example of adding comments (1), as well as the additional information field (2). Comments are added to the point indicated by the meter by using the "Add comment" button. The meter (3) can be moved by dragging your mouse or by clicking on the picture at the desired point. The comment can be seen on the curve as a green note. The complete comment can be viewed by bringing the mouse on top of the green note. The note can be modified or removed by double clicking. Short general information about a client's condition, events, or other relevant information can be written in the additional information field at the bottom of the screen. Additional information can be modified or removed.

9.2 Printing of curve information

The simplest way of reporting events is to print curve information for a specific time period on paper from either the post or weekly analysis window. Figure 19 shows an example of a print out taken from a situation where there was a rapid change in circadian rhythm due to the poor health of the user.

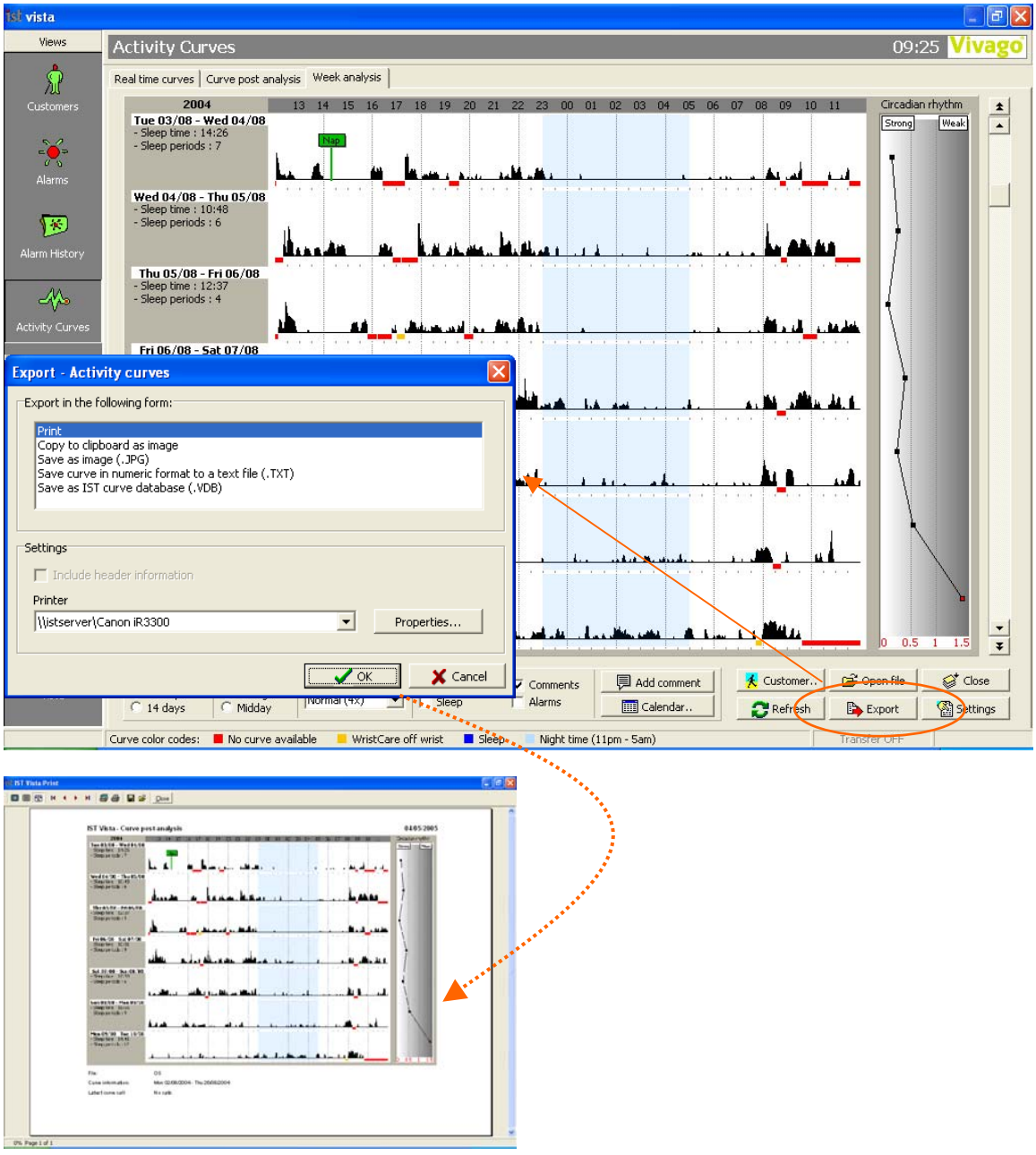


Figure 19. Printing curve information on paper from the Vista program.

The print out can be kept as part of client records or can be attached to other documents and given to the appropriate recipient as normal.

9.3 Adding curve information to other programs

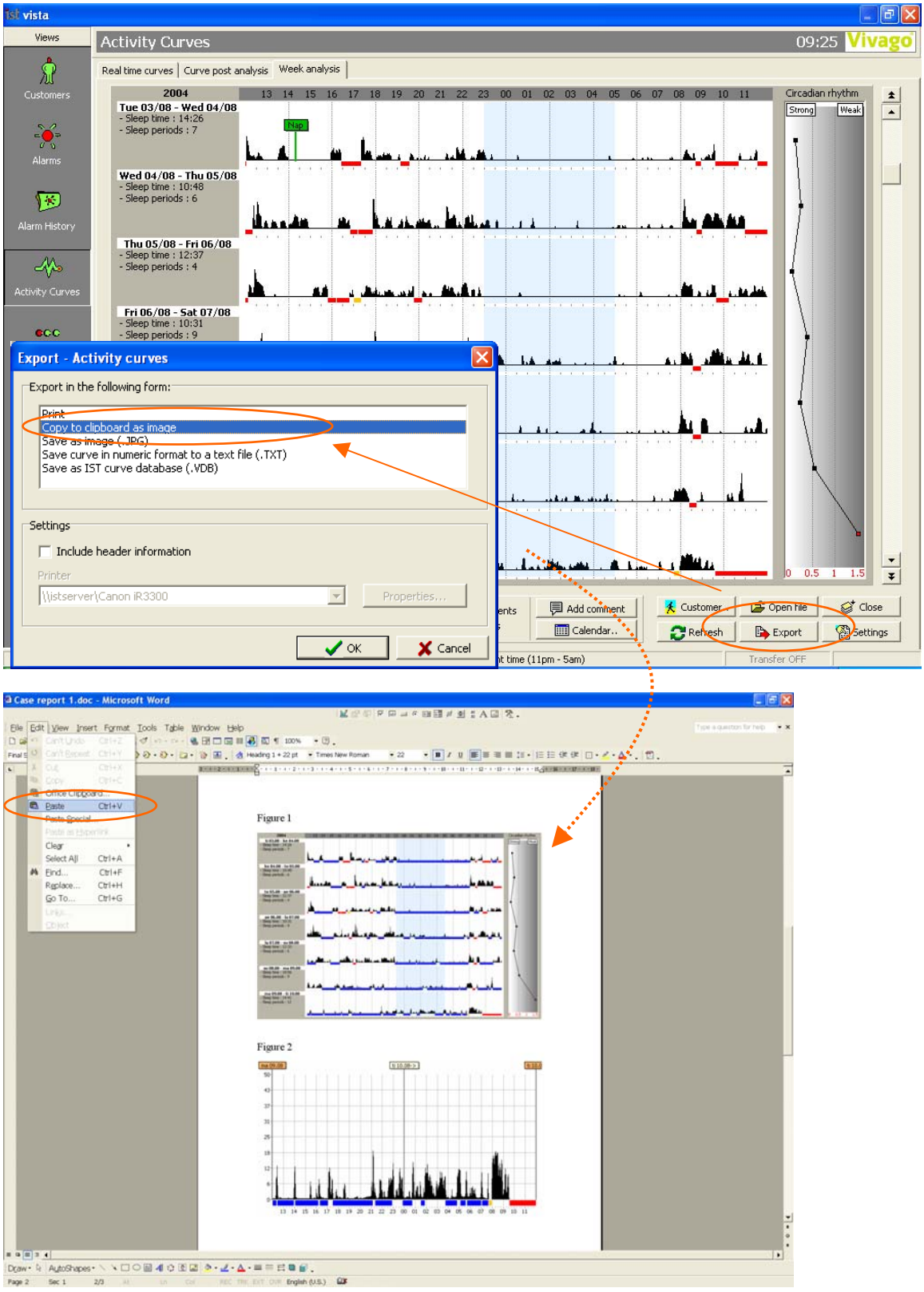


Figure 20. Transferring curve information to MS Word using the clipboard.

If you want to transfer curve information to other programs, this can be done with the clipboard, or by first saving the information as a picture file (.jpg- format) in the desired file and then attaching this picture file to another document made using MS Word, for example. Figure 20 shows an example of using the clipping table. You can chose either to copy onto the clipboard or to a separate file from the “Export” menu in the Vista program.

9.4 Activity report

By using a separate word processing program, you can make, for example, an activity case report as shown in figure 21 for each customer.

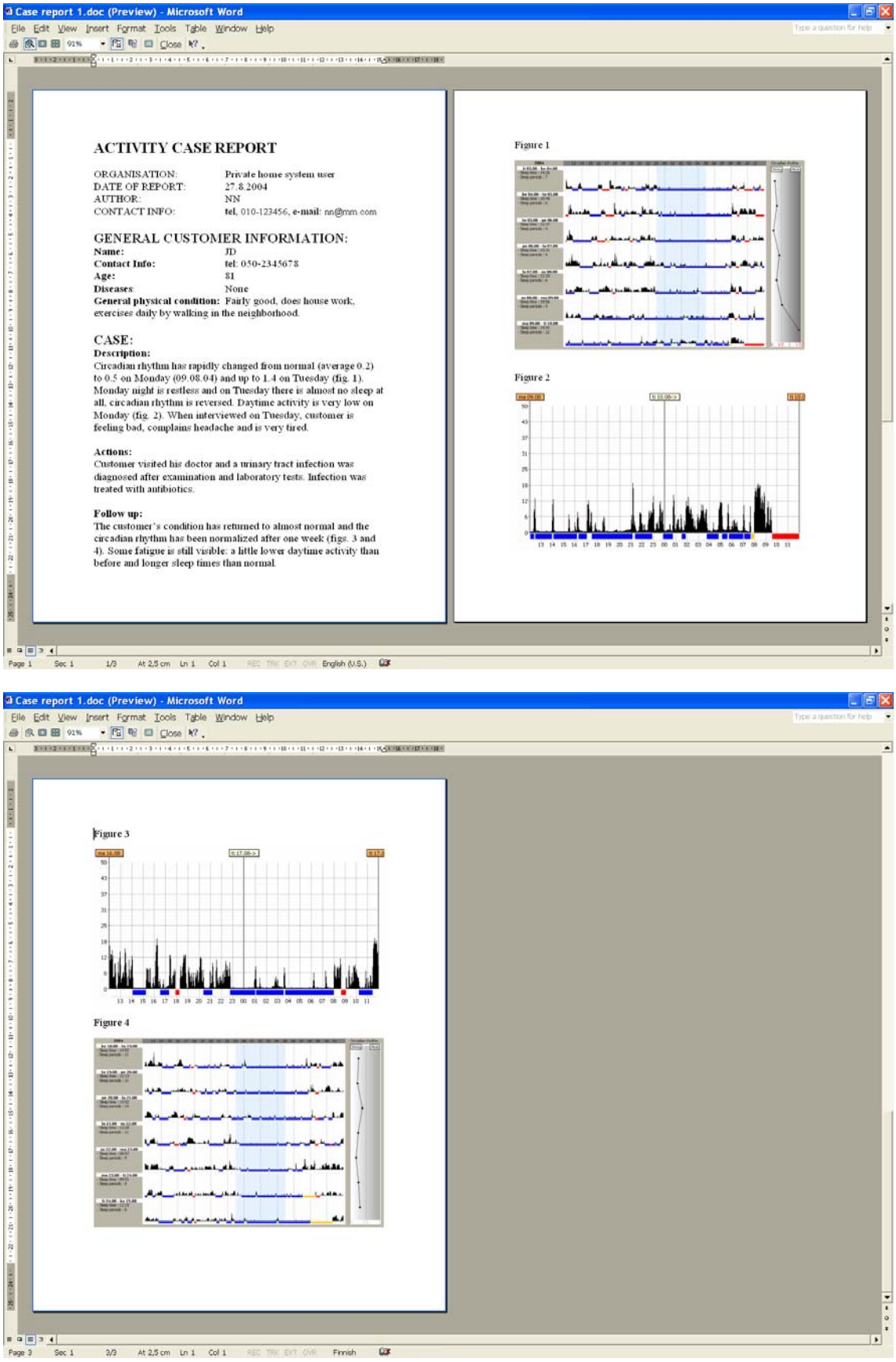

Case report 1.doc (Preview) - Microsoft Word
File Edit View Insert Format Tools Table Window Help
ACTIVITY CASE REPORT
ORGANISATION: Private home system user
DATE OF REPORT: 27.8.2004
AUTHOR: NN
CONTACT INFO: tel. 010-123456, e-mail: nn@mm.com
GENERAL CUSTOMER INFORMATION:
Name: JD
Contact Info: tel: 050-2345678
Age: 81
Diseases: None
General physical condition: Fairly good, does house work, exercises daily by walking in the neighborhood.
CASE:
Description:
Circadian rhythm has rapidly changed from normal (average 0.2) to 0.5 on Monday (09.08.04) and up to 1.4 on Tuesday (fig. 1). Monday night is restless and on Tuesday there is almost no sleep at all, circadian rhythm is reversed. Daytime activity is very low on Monday (fig. 2). When interviewed on Tuesday, customer is feeling bad, complains headache and is very tired.
Actions:
Customer visited his doctor and a urinary tract infection was diagnosed after examination and laboratory tests. Infection was treated with antibiotics.
Follow up:
The customer's condition has returned to almost normal and the circadian rhythm has been normalized after one week (figs. 3 and 4). Some fatigue is still visible: a little lower daytime activity than before and longer sleep times than normal.
Figure 1
Figure 2
Case report 1.doc (Preview) - Microsoft Word
Figure 3
Figure 4

Figure 21. Activity case report.

10. REFERENCES

The sleep and circadian rhythm of elderly people and its significance in care has been actively researched. Results indicate that circadian rhythm and sleep represent the well being of elderly people in many ways. By taking this into consideration, the well being and more independent living of individuals both at home and in facilities can be greatly improved. The IST Vivago system's activity measurement has been scientifically validated (/9/ and /10/) to be equivalent to actigraphs in observing circadian rhythm. The actigraph, which has been in clinical use for a long time, is an established method for studying sleep and circadian rhythm. The references listed below are only a small part of the studies that have been done, but give a good overview of the topic.

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/4/ Phillips B, Ancoli-Israel S. Sleep disorders in the elderly. Review. Sleep Medicine 2001; 2: 99-114

/5/ Brassington GS, King AC, Bliwise DL. Sleep problem as a risk factor for falls in a sample of community-dwelling adults aged 64-99 years. JAGS 2002; 48(10): 1234-1240

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/10/ Paavilainen P, Korhonen I, Cluitmans L, Lötjönen J, Särelä A & Partinen M. Circadian Rhythm in Demented and Non-demented Nursing Home Inhabitants Measured by IST Vivago® WristCare Activity Signal. The International Conference on Aging, Disability, and Independence, 4-6 December 2003, Washington DC, USA.